77/37

FISHING INDUSTRY RESEARCH TRUST ACCOUNT

FINAL REPORT ON RESEARCH PROJECT 1977/78

1. Title of Project:-

   Research on technology of processing rock lobster in relation to drowning before tailing.

2. Name of Applicant:-

   Commonwealth Scientific and Industrial Research Organisation and the Australian Department of Primary Industry.

3. Divisions:-

   CSIRO Division of Food Research and DPI Fisheries Division.

4. Project:

   To investigate the effects of drowning rock lobsters before tailing.

5. Name of Person Responsible for Programme:-

   Dr J.N. Olley, Ph.D., D.Sc., Principal Research Scientist.

6. Qualifications of Staff to be Employed on the Programme:-

   Mr H.A. Bremner, ARMIT (Applied Chem., Food Tech.), Experimental Officer.

   Ms G. Veith, B.Sc., Experimental Officer.

7. Location of Operations:-

   CSIRO Tasmanian Food Research Unit, "Stowell", Stowell Avenue, Hobart.

8. Date Project Commenced:- 1/7/77

9. Date of Project completion:-

   Experimental work ceased 30/6/78. At the time of writing (22/11/78) the results are being prepared for publication to the Journal of Food Science.

CSIRO DIVISION OF FOOD RESEARCH

TASMANIAN FOOD RESEARCH UNIT, HOBART.

FINAL REPORT ON RESEARCH PROJECT

Research on Technology of Processing Rock Lobster in Relation to Drowning before Tailing.

Introduction

The background to this project has been thoroughly covered in last years progress report.

Methods and Materials

These were covered in detail in the previous progress report. In summary, Southern rock lobsters were either tailed while live (Treatment 1) or were tailed after being held in slush ice ($0^{o}C$) for 1h (Treatment 2), 20h (for Treatment 3) or 48h (Treatment 4).

The tails were deveined, washed, drained and then frozen in polythene bags. At each stage the lobster tails were weighed and complete records of yields were calculated. They were sorted into 5 groups and a group was removed from frozen storage for taste panel evaluation after 1, 6, 14, 28 and 40 weeks in storage at $-18^{o}C$. The meats were served cold after cooking the previous day in boiling 3% salt solution.

The taste panel judged the colour, aroma, off aroma, flavour, off flavour, toughness, moisture and overall acceptability of the meats according to the score sheet (Table 1).

Results

The yield results are included in Tables 2 and 3. It is obvious that increased time of holding in slush ice results in increased uptake of water in the tail. The imbibed water is then lost partly on thawing and partly on cooking such that lobster tails from treatment 4 show a slightly lower yield of cooked flesh based on the whole

lobster. Tails from treatments 3 and 4 also lose more solids, i.e. soluble protein, ions, amino acids, etc. in the thaw liquor. The amounts lost were not sufficient to affect any of the attributes as judged by the taste panel.

The taste panel results are summarised in Figure 1. The taste panel considered that there were no differences of practical consequence between the cooked meats of tails from all the treatments for any of the attributes judged nor was there any difference in acceptability. Likewise there were no changes of practical consequence with storage time in any of the attributes. Flesh from all treatments could be said to be of high quality. The results of chemical tests carried out on samples of lobster flesh also confirmed the stability in frozen storage of the muscle proteins i.e. the flesh of rock lobster meats.

Conclusion

The study has shown that lobster may reasonably be held in slush ice ($0^{\circ}C$) for considerable periods of time before being tailed.

In view of the suspected fragility of the hepatopancreas in treatment 4 and the obvious swelling of the tail muscles it is suggested that holding in slush ice be restricted to a maximum of 24 hours.

Table 1 - Taste panel sheet descriptive terms and corresponding numerical scores

Score	Lobster aroma	Off-aroma	Lobster flavor	Off-flavor
9	Extremely strong lobster aroma	Extremely strong	Extremely strong lobster flavor	Extremely strong
8	Very strong lobster aroma	Very strong	Very strong lobster flavor	Very strong
7	Strong lobster aroma	Strong	Strong lobster flavor	Strong
6	Moderately strong lobster aroma	Moderately strong	Moderately strong lobster flavor	Moderately strong
5	Moderate lobster aroma	Moderate	Moderate lobster flavor	Moderate
4	Moderately weak lobster aroma	Moderately weak	Moderately weak lobster flavor	Moderately weak
3	Weak lobster aroma	Weak	Weak lobster flavor	Weak
2	Very weak lobster aroma	Very weak	Very weak lobster flavor	Very weak
1	No lobster aroma	None	No lobster flavor	None

Score	Color	Toughness	Moisture	Acceptability
9	Characteristic bright white or pink color	Extremely tough	Extremely wet	Excellent
8	Slightly lacking characteristic color	Very tough	Very wet	Very good
7	Off white color	Tough	Wet	Good
6	Off white/yellow color	Slightly tough	Slightly wet	Below good, above fair
5	Yellow/grey discoloration	Characteristic lobster texture	Characteristic moistness	Fair
4	Grey discoloration	Very slightly soft	Slightly dry	Below fair, above poor
3	Grey/brown discoloration	Soft	Dry	Poor
2	Marked discoloration	Very soft	Very dry	Very poor
1	Severe discoloration	Extremely soft	Extremely dry	Extremely poor

Table 2 - Treatment effects on yields over the whole experiment

Yield (%)	Treatment 1	2	3	4	Statistical least significant difference for p<0.05	p<0.01	p<0.001
	Yield based on whole lobster						
Initial tail yield[a]	36.0	37.0	38.1	40.6	0.9	1.2	1.6
Packed tail yield[a]	36.7	37.6	38.3	40.2	0.9	1.2	1.6
Thawed tail yield[bc]	34.5	35.5	35.5	35.9	0.9	1.2	1.6
Cooked tail yield[b]	31.1	31.8	30.6	29.1	1.0	1.3	1.6
Cooked flesh yield[b]	23.8	24.4	23.8	22.4	0.7	1.0	1.3
	Yield based on frozen tail						
Thawed tail yield[bc]	95.2	95.2	93.0	90.1	0.6	0.8	1.0
Cooked tail yield[b]	86.7	86.3	81.1	73.9	1.3	1.8	2.3
Cooked flesh yield[b]	66.5	66.1	63.1	57.0	1.3	1.7	2.2

[a] 48 lobsters per treatment

[b] 45 lobsters per treatment

[c] A slight decrease in thawed tail yield was found with increased storage time see Fig. 3 and text

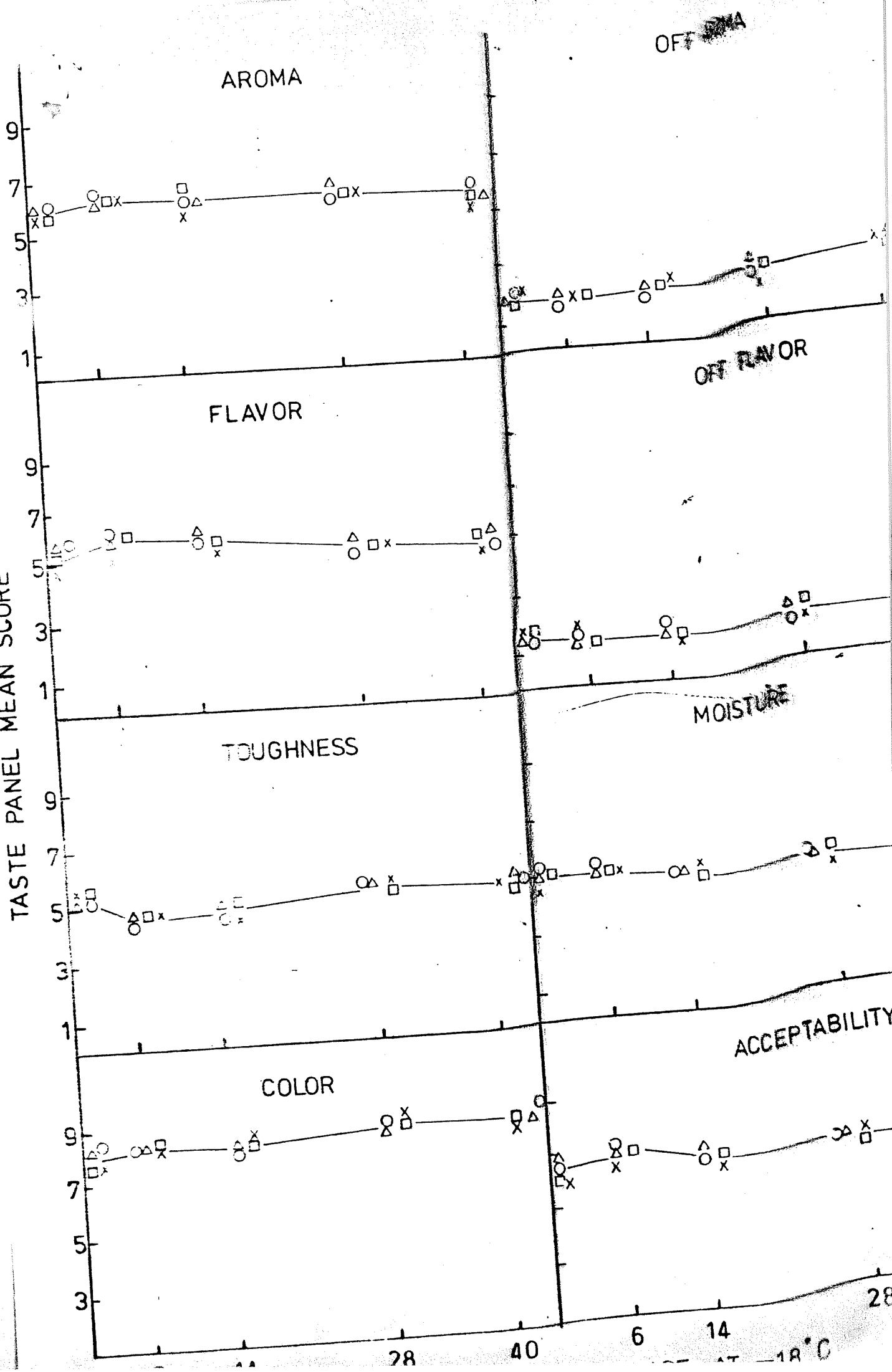
Table 3 - Weight gains and losses in processing steps

Processing step and calculation	Treatment 1 %	2 %	3 %	4 %
Holding lobster in slush ice[a]	NA	ND	+9.3	+12.9
Holding tail in ice water[b] 20 min., drained 20 min.	+1.7	+1.5	+0.5	-2.0
Thawing 36 h 4-5°C[b]	-4.8	-4.8	-7.0	-9.9
Cooking[b]	-8.9	-9.4	-12.8	-18.0

NA not applicable

[a] ND not determined; figures based on 12 samples treatment 3, 10 samples treatment 4

[b] Figures based on 45 samples per treatment


AROMA
OFF AROMA
FLAVOR
OFF FLAVOR
TOUGHNESS
MOISTURE
COLOR
ACCEPTABILITY
TASTE PANEL MEAN SCORE
9
7
5
3
1
28
40
6
14
28

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EFFECTS ON QUALITY ATTRIBUTES OF HOLDING ROCK LOBSTERS IN SLUSH ICE BEFORE TAILING

H. ALLAN BREMNER and GAYLENE VEITH

ABSTRACT

Taste panel evaluation, yield measurements and analytical tests were carried out on the frozen stored (−18°C) tail flesh from southern rock lobsters (*Jasus novaehollandiae* Holthius) which had been tailed while live (no holding period in slush ice) or after being held in slush ice (0°C) for periods of 1, 18 or 48 hr before being tailed. The taste panel results did not reveal any differences in the organoleptic quality of frozen lobster flesh subjected to various holding periods in slush ice or with subsequent frozen storage at −18°C for up to 40 wk. Holding lobsters in slush ice for 48 hr resulted in a lower yield of cooked tail flesh, whereas holding for 18 hr did not affect the yield of cooked tail flesh or its edible quality.

INTRODUCTION

FROZEN ROCK LOBSTER tails are a major Australian fishery export worth $A56 million annually (Anon. 1978). About one-fifth of the value comes from the southern rock lobster (*Jasus novaehollandiae* Holthius) caught mainly in the gulf area of South Australia. The lobsters are kept on board in recirculating seawater wells and landed alive at a number of minor fishing ports, most of which are too small to warrant construction of an export licensed processing factory. The catch has often to be transported long distances along dusty unmade roads to approved factories. In addition, catches may have to be held overnight, or longer, before they can be processed. Since the peak season is in summer the processor is faced with difficult holding and transport problems. Therefore the practice of holding the lobsters in covered bins of ice or slush ice (an ice/water mix) has been adopted by some processors to minimize bacterial growth and biochemical decomposition. Rock lobsters held in slush ice 'drown' by osmotic imbibition of water, since they have limited ability to regulate their internal osmotic environment. Even immersion in 75% sea water results in considerable mortality (Dall, 1974). The effects of this imbibed water on the quality of the final product are unknown.

The Fisheries Division of the Australian Department of Primary Industry, which regulates the licensing of export premises and approves processing methods, requested that work be undertaken to examine the effects of holding lobsters in slush ice. This study was designed to provide accurate yield data and taste panel evaluation of the frozen stored lobster tails. Chemical analysis of the tissue and thaw liquor was also done to ascertain whether cell damage had occurred during the holding period.

MATERIALS & METHODS

THE LOBSTERS (*J. novaehollandiae* Holthius) were caught close to Hobart, Tasmania over a period of 2–3 days in Aug., 1977. They were kept alive on the boat in a recirculating seawater well (seawater temp ≃ 12°C) and, when the boat docked, were bagged and transported 5 km to the commercial factory where the treatments and processing were done. They were all vigorously alive at the start of the sorting and allocation to treatments. All lobsters were males, the season being closed for taking of females.

From the total catch, 180 lobsters were tagged with numbers, weighed (± 1g, 'live weight') and sorted into three equal size groups, small (570–680g), medium (680–750g), and large (750–1150g). They were then allocated to four treatment groups of 45 lobsters, 15 from each size group. The treatments were (1) tailed while live, (2) held 1 hr in slush ice, then tailed, (3) held 18 hr in slush ice, then tailed, and (4) held 48 hr in slush ice, then tailed.

The severed tails were immediately deveined, washed, weighed ('initial tail weight') and then placed in ice water (0°C) for 20 min. After a 20 min draining period the tails were weighed, packed in polyethylene sachets ('packed tail weight'), and frozen at −20°C. The day after completion of the treatments the frozen tails were taken to the CSIRO Tasmanian Food Research Unit where they were randomly allocated into five equal groups of 36 (4 treatments × 3 size groups × 3 replicates), and stored at −18°C. The first group was tested the following week (designated as wk 1 for all treatments) and the other groups after 6, 14, 28, and 40 wk.

Thawing, cooking and preparation

After the designated storage time the tails were thawed for 36 hr at 4–5°C and were then re-weighed (thawed weight). The thawed fluid (drip) was collected from the 12 largest tails at each storage time. Flesh samples of the abdominal muscle protruding from the butt end were taken from these large tails.

The tails were cooked in constantly boiling 3% salt solution for 11, 12 and 14 min for small, medium and large sizes respectively to an internal temperature in the range 60–65°C. These cooking times were chosen on the basis of South African work (Atkinson, 1973) and were confirmed as suitable in preliminary experiments using thermocouples in the flesh and visual and organoleptic assessment of the cooked flesh.

—Continued on next page

Table 1—Taste panel sheet descriptive terms and corresponding numerical scores

Score	Lobster aroma, off-aroma, Lobster flavor, and off-flavor	Color
9	Extremely strong	Characteristic bright white or pink color
8	Very strong	Slightly lacking characteristic color
7	Strong	Off white color
6	Moderately strong	Off white/yellow color
5	Moderate	Yellow/grey discoloration
4	Moderately weak	Grey discoloration
3	Weak	Grey/brown discoloration
2	Very weak	Marked discoloration
1	None	Severe discoloration

Score	Toughness	Moisture	Acceptability
9	Extremely tough	Extremely wet	Excellent
8	Very tough	Very wet	Very good
7	Tough	Wet	Good
6	Slightly tough	Slightly wet	Below good, above fair
5	Characteristic lobster texture	Characteristic moistness	Fair
4	Slightly soft	Slightly dry	Below fair, above poor
3	Soft	Dry	Poor
2	Very soft	Very dry	Very poor
1	Extremely soft	Extremely dry	Extremely poor

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Table 2—Effects of holding lobsters in slush ice on tail yield

	Holding time (hr) in slush ice				Least significant difference[a] for		
	0	1	18	48	$p < 0.05$	$p < 0.01$	$p < 0.001$
	Yield as % of whole live lobster						
Initial tail yield	36.0	37.0	38.1	40.6	0.9	1.2	1.6
Packed tail yield	36.6	37.6	38.3	40.2	0.9	1.2	1.6
Thawed tail yield	34.5	35.5	35.5	35.9	0.9	1.2	1.6
Cooked tail yield	31.1	31.8	30.6	29.1	1.0	1.3	1.6
Cooked flesh yield	23.8	24.4	23.8	22.4	0.7	1.0	1.3
	Yield as % of packed tail						
Thawed tail yield	95.2	95.2	93.0	90.1	0.6	0.8	1.0
Cooked tail yield	86.7	86.3	81.1	73.9	1.3	1.8	2.3
Cooked flesh yield	66.5	66.1	63.1	57.0	1.3	1.7	2.2

[a] After analysis of variance

After cooking, the tails were rapidly cooled for 5–7 min in slush ice then in crushed ice for 25 min. They were then drained and stored overnight on covered racks at 1°C. The tails were weighed (cooked weight) and the cuticle removed and both flesh and cuticle weighed. The flesh was trimmed and cut into 6 segments for taste panel evaluation.

Analytical

Flesh pH was determined by insertion of a cheese electrode (pH Meter 20, Radiometer, Copenhagen) into the abdominal oblique muscle protruding from the cuticle (butt end). Recordings were made immediately after the separation of the tail from the thorax and also before freezing and after thawing. The pH of the thaw drip from tails stored 14, 28, and 40 wk was also recorded. The saline extractable protein (SEP) of the tail muscle was extracted as described by Anderson and Ravesi (1968). Both SEP and thaw drip protein were estimated using the biuret method of Layne (1957). Potassium levels in the tissue and thaw drip were estimated by flame emission spectroscopy.

Taste panel

The taste panel, which comprised 18 members of staff, was asked to score the samples for the attributes of characteristic lobster color, characteristic lobster aroma, characteristic lobster flavor, off-aroma, off-flavor, toughness, moisture, and acceptability, each on a 9-point scale (see Table 1). These were considered to be the major sensory attributes which would affect eating quality. The importance of estimating the attributes of off-aroma and off-flavor has recently been shown by Laslett and Bremner (1979). Note that in the toughness and moisture categories a score of 5 (mid-point) represents characteristic toughness and moisture respectively, whereas for the other categories the higher the score the greater the attribute. The panel was trained before the experiments on freshly processed lobster, equivalent to treatments 1 and 2, and on lobster that had been stored 12–16 wk at −20°C. Further familiarization sessions were held before the 28 and 40 wk removals using available lobster tails, equivalent to treatment 2, that had been stored about 4 wk at −20°C. Three sessions were held on each taste day at 0930, 1130, and 1430 hr, with samples from only one size group at each session. The order of presentation was balanced at each session and randomized throughout the whole experiment.

At each session each panelist received four samples (one per treatment) in separate foil-covered glass jars with the abstract labelling (Δ, X, □ or O). In order to reduce end-to-end and size variation in segments, each taster received segments from the same relative position on each of the four tails.

Statistical

The yields, the results of chemical analysis and taste panel results were all subjected to analysis of variance.

RESULTS & DISCUSSION

Process observations

The lobsters held in slush ice took up water, and in treatments 3 and 4 this increased the weight of the animals

Table 3—Effect of holding lobsters in slush ice on pH of lobster tail muscle and drip

Processing step	Holding time (hr) in slush ice				Least significant difference[a] for		
	0	1	18	48	$p < 0.05$	$p < 0.01$	$p < 0.001$
Freshly tailed[b] and deveined	7.26	7.08	7.24	6.78	0.07	0.09	0.12
Before freezing[b]	7.28	6.86	7.15	6.71	0.07	0.09	0.11
After thawing[b]	6.66	6.59	6.68	6.66	0.06	0.07	0.10
After thawing[c]	6.60	6.64	6.66	6.63	0.06	0.09	0.10
Drip[d]	6.61	6.54	6.67	6.67	0.06	0.07	0.10

[a] After analysis of variance
[b] n = 180
[c] n = 36, 1 wk at −18° C
[d] n = 60 (12 large lobsters × 5 storage times)

Table 4—Effects of holding lobsters in slush ice on solids, protein, and potassium in thaw drip expressed as percentage of frozen tail flesh

	Holding period (hr) in slush ice				Least significant difference[a] for		
	0	1	18	48	$p < 0.05$	$p < 0.01$	$p < 0.001$
Solids	0.52	0.48	0.67	0.95	0.16	0.22	0.29
Protein	0.30	0.30	0.46	0.58	0.10	0.14	0.18
Potassium	0.010	0.010	0.014	0.019	0.003	0.005	0.006

[a] After analysis of variance

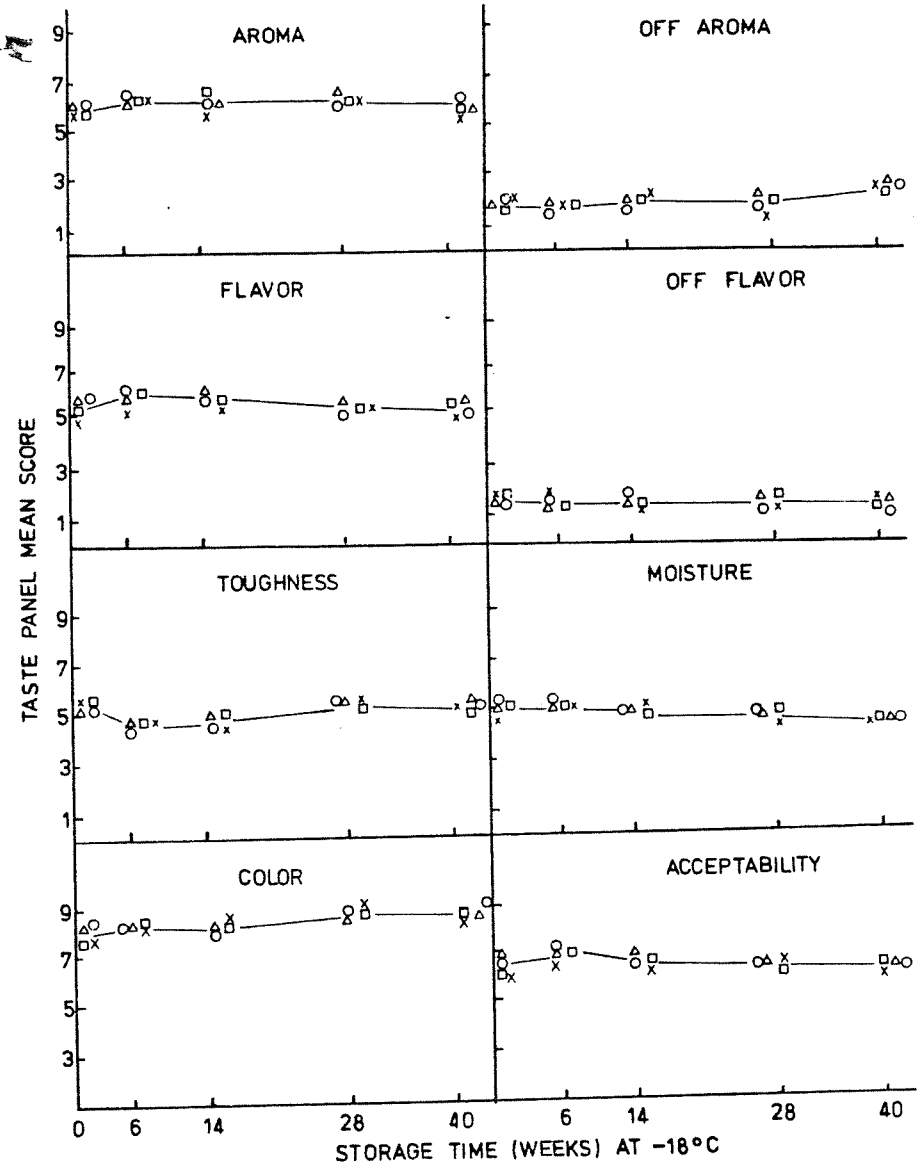

Fig. 1—Mean taste panel scores at each storage time, for lobster tails subjected to the following four treatments: lobsters tailed while live (Δ); lobsters tailed after 1 hr in slush ice (O); lobsters tailed after 18 hr in slush ice (X); lobsters tailed after 48 hr in slush ice (□). To allow greater clarity some symbols have been displaced laterally.

by 9.3% (mean of 12 lobsters) and 12.9% (mean of 10 lobsters) respectively. After tailing, more flesh was left in the body of the lobsters in treatment 4. The imbibed water caused the tail flesh to swell making it more difficult to devein the tails cleanly, particularly those from treatment 4. Furthermore, in most of these animals the tail fans (uropods) also had noticeably swollen and could be burst to produce a jet of diluted congealed blood. Subjective appraisal of the digestive gland from the lobsters in treatment 4 suggested that the gland was more fragile than from those in the other treatments. This gland, sometimes termed the hepatopancreas, contains powerful proteolytic enzymes. If the gland is ruptured, these enzymes will be released on to the tail flesh where they can act on the tissue even during frozen storage, giving rise to staining, off-flavor, and considerable deterioration in texture (Wessels and Olley, 1973; Olley et al., 1973).

Treatment effects on yields

The yields are shown in Table 2. The initial tail yield increased with time of holding the lobsters in slush ice. Cooling the tail in ice water for 20 min after the deveining operation, followed by draining 20 min, resulted in small increases in yield in treatments 1, 2, and 3 but a net loss in treatment 4. The loss in weight as drip during thawing was much higher in treatments 3 and 4. Treatment 4 resulted in significantly lower cooked tail yields ($p < 0.01$) and flesh yields ($p < 0.001$) than the other treatments.

At all processing stages the yields were significantly greater ($p < 0.01$) with increasing lobster size. Analysis of variance showed that there were no interactions between size and treatments, indicating that the effects of holding lobsters in slush ice were consistent for both small and large lobsters. The results for thawing and cooking losses for tails in treatment 1 are essentially the same as those reported by Montgomery and Sidhu (1973) for lobster tails similarly treated.

Water taken up by the tail flesh during holding in slush ice is eventually released either on thawing or on cooking. Where thaw losses were high due to treatment they were not compensated for by low cooking losses (Table 2).

pH and protein

Some explanation of the large differences in drip loss between treatments was sought from the pH and level of SEP since these are known (Hamm, 1960) to have a strong influence on the water-holding capacity of flesh.

The pH values of the lobster flesh after the various treatments are listed in Table 3. The initial pH for the treatment 1 tails (pre-rigor) was 7.26 which concurs with the value of

7.2 reported for muscle of the same species by Sidhu et al. (1974). The initial pH for the tail muscle in treatments 2 and 4 is consistent with the normal decrease in pH that results from postmortem glycolysis but the high values of the flesh in tails from treatment 3 are not explicable. This precludes explanation of the differences between treatments in the amount of drip lost in terms of pH of the flesh at the time of freezing.

After 1 wk in store the pH of the thawed tail flesh from all the treatments was in the region 6.60–6.66 and similar values (Table 3) were obtained at subsequent storage times. This again precludes explanation of the drip loss differences between the treatments in terms of the pH of the thawed flesh. The glycolytic changes which brought the flesh to near pH 6.6 must have occurred during freezing and thawing since 1 wk at −18°C would not be sufficient time for the rigor changes that can occur in frozen stored lobster flesh (James and Olley, 1969–70; 1970–71) to have taken place. Many enzymic processes occur faster in the zone of thermal arrest (−5 to −1°C) when flesh is part frozen (Fennema, 1975). For example, over 40 yr ago Sharp (1935) demonstrated maximum rates of lactate production in haddock flesh held at −3°C. Sidhu et al. (1974) also found 6.6 to be the ultimate pH in lobster flesh at 0°C. At this temperature only 60% of the glycogen was converted to lactate, whereas at 15°C and 20°C, 90% was converted with consequent fall in the pH to 6.1. Presumably at 0°C alternate pathways of glycolysis, which do not lead to lactate production, are in operation, as discussed by Sidhu et al. (1974). The pH of the drip closely reflected that of the thawed tissue.

Analysis of variance also indicated no differences between treatments in the SEP levels in the tissue which varied from 15–17% of the thawed flesh weight (mean 16%). After 28 wk storage the levels were as high as the initial values but after 48 wk storage the levels in all treatments were significantly lower ($p < 0.01$) by 2–5%. It is apparent that, as reported by James and Olley (1969–70), lobster muscle proteins are stable in frozen storage. With these high levels of SEP and high pH the flesh could be expected to have a high water-holding capacity.

Analyses of drip

The drip, from the largest sized lobsters stored 6, 14, 28, and 40 wk, was analyzed for total solids, protein, and potassium, and these results are expressed in Table 4 as a percentage of the frozen flesh weight. These amounts of solids, protein, and potassium did not alter with time of frozen storage and the values for each treatment reflect the drip volumes. Indeed the drip from all the treatments was fairly constant in composition with a mean solids, protein, and potassium content of 7.3, 4.7, and 0.15g/100g drip respectively. Awad et al. (1969) found a similar phenomenon for whitefish where although drip from different fish varied in volume, its composition remained similar.

Taste panel

The taste panel results are displayed in Figure 1. There were no differences of practical significance between the treatments. This is in keeping with the stable nature of the proteins and with the observation that changes in the levels of the flavorous nucleotides (e.g. inosine monophosphate and hypoxanthine) are negligible up to 48 hr at 0°C (Bremner et al., 1978–79).

The taste panel's judgments were consistent and no differences in acceptability between the treatments were detected. Acceptability did not decline with frozen storage time. Montgomery and Sidhu (1973) also found that acceptability of lobster tail meats, treated comparably to those in treatment 1, did not decline with storage at −20°C for up to 32 wk.

CONCLUSIONS

HOLDING LOBSTERS in slush ice results in water uptake in both the animal as a whole and the tail flesh. Longer holding periods result in greater water uptake. This water is lost partly on thawing and partly on cooking with concomitant loss of water-extractable muscle constituents both extra- and intra-cellular in origin. High thaw losses are not compensated for by lower cooking losses and this may have implication for other seafoods, e.g. prawns, that are held for some time either on board ship or in holding tanks at factories in ice water or chilled sea water.

Compared with lobsters tailed live, those held for 48 hr in slush ice gave higher initial yields but when thawed and cooked the accumulated losses resulted in a lower yield of cooked flesh. With lobsters held for 18 hr the cooked flesh yield was not affected. Taste panel evaluation showed that the meat from all four treatments was rated equally in all variables including acceptability and that for 40 wk storage at −18°C no changes of practical significance had occurred.

Storage of lobsters in slush ice for up to 18 hr causes no observable loss in the edible quality of the tail flesh and results in the same yield of cooked flesh as for lobsters tailed while live. It is thus a useful method for overcoming transport and supply problems.

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